

What is Claimed is:

- 1                   1. A multi-layer tube, comprising:  
2                   a metal tube having an outer surface;  
3                   a zinc layer bonded to the metal tube outer  
4 surface, wherein the zinc layer is selected from the  
5 group consisting of zinc plating, zinc nickel alloys,  
6 zinc cobalt alloys, zinc aluminum alloys, and mixtures  
7 thereof;  
8                   a surface treatment layer bonded to the zinc  
9 layer, wherein the surface treatment layer is selected  
10 from the group consisting of a zinc/aluminum/rare earth  
11 alloy, phosphate, chromate, and mixtures thereof;  
12                   a priming layer;  
13                   a first polymeric layer bonded to the priming  
14 layer, wherein the first polymeric layer is selected from  
15 the group consisting of thermoplastic elastomers,  
16 ionomers, nylons, fluoropolymers, and mixtures thereof;  
17 and  
18                   a second polymeric layer bonded to the first  
19 polymeric layer, wherein the second polymeric layer is  
20 selected from the group consisting of nylons,  
21 thermoplastic elastomers, fluoropolymers, and mixtures  
22 thereof.
- 1                   2. The multi-layer tube as defined in claim 1,  
2 further comprising a third polymeric layer interposed  
3 between, and bonded to the first and second polymeric  
4 layers, wherein the third polymeric layer is selected  
5 from the group consisting of ionomers, nylons, ethylene  
6 vinyl alcohol, polyolefins, and mixtures thereof.
- 1                   3. The multi-layer tube as defined in claim 1,  
2 wherein the zinc layer has a thickness ranging between  
3 about 10 to 25 microns.

1           4. The multi-layer tube as defined in claim 1,  
2 wherein the surface treatment layer has a weight ranging  
3 between about 37.3 g/m<sup>2</sup> and about 97.7 g/m<sup>2</sup>.

1           5. The multi-layer tube as defined in claim 1  
2 wherein the first and second polymeric layers, combined,  
3 have a thickness ranging between about 75 to 300 microns.

1           6. The multi-layer tube as defined in claim 5  
2 wherein the first and second layer thickness ranges  
3 between about 125 to 250 microns.

1           7. The multi-layer tube as defined in claim 2  
2 wherein the first, second and third polymeric layers,  
3 combined, have a thickness ranging between about 75 to  
4 300 microns.

1           8. The multi-layer tube as defined in claim 7  
2 wherein the first, second and third layer thickness  
3 ranges between about 125 to 250 microns.

1           9. The multi-layer tube as defined in claim 1  
2 wherein the zinc/aluminum/rare earth alloy of the surface  
3 treatment layer consists essentially of:  
4           between about 85% and about 97% Zn;  
5           between about 4% and about 15% Al; and  
6           at least about 5 ppm of a rare earth-containing  
7 alloy.

1           10. The multi-layer tube as defined in claim 1  
2 wherein the first polymeric layer consists essentially of  
3 an ionomer and a nylon.

1           11. The multi-layer tube as defined in claim  
2 10 wherein the ionomer is ethylene methacrylic acid  
3 copolymer--partial metal salt, and wherein the nylon is  
4 Nylon 12.

1           12. The multi-layer tube as defined in claim  
2       11 wherein the ethylene methacrylic acid copolymer--  
3       partial metal salt comprises between about 10% and about  
4       70% of the first polymeric layer, and wherein the Nylon  
5       12 comprises between about 90% and about 30% of the first  
6       polymeric layer.

1           13. The multi-layer tube as defined in claim  
2       11 wherein the second polymeric layer consists  
3       essentially of a nylon.

1           14. The multi-layer tube as defined in claim  
2       13 wherein the second polymeric layer consists  
3       essentially of Nylon 12.

1           15. A process for manufacturing a multi-layer  
2       tubing for conveying fluids comprising the step of:  
3               extruding multiple layers of a melt-processible  
4       thermoplastic to a pretreated metal tube having an  
5       external surface with at least a zinc based coating, a  
6       sealant coating on top of the zinc based coating, and a  
7       primer coating on top of the sealant coating.

1           16. The process of claim 15 wherein the melt-  
2       processable thermoplastic is selected from the group  
3       consisting of Nylon 12, Nylon 6, zinc chloride resistant  
4       Nylon 6, thermoplastic elastomers, fluoropolymers, and  
5       mixtures thereof.

1           17. The process as defined in claim 16 wherein  
2       the primer coating is applied by an airless spray system  
3       in a closed atmosphere, wherein substantially no volatile  
4       organic compounds escape into the atmosphere.

1           18. A process for manufacturing a multi-layer  
2       tubing for conveying fluids in a vehicle system  
3       comprising the steps of:

4 coating a metal tube with a zinc based coating  
5 selected from a group consisting of zinc, zinc-nickel  
6 alloy, zinc-cobalt alloy, zinc-aluminum alloy, and  
7 mixtures thereof;

8 sealing the zinc based coating on the metal  
9 tube with at least one sealant coating selected from the  
10 group consisting of a phosphate surface treatment, a  
11 chromate surface treatment, a zinc-aluminum alloy surface  
12 treatment, and combinations thereof;

13 applying a primer after the sealing step;

14 coextruding at least one melt-processible  
15 thermoplastic layer onto the pretreated metal tube with  
16 the at least one layer overlying the pretreated metal  
17 tube, wherein the first layer is selected from the group  
18 consisting of Nylon 12, Nylon 6, zinc chloride resistant  
19 Nylon 6, thermoplastic elastomers, fluoropolymers,  
20 ionomers, and mixtures thereof; and

21 applying vacuum pressure between the pretreated  
22 metal tube and the melt-processible thermoplastic during  
23 the extruding step to draw the thermoplastic into  
24 intimate contact with the pretreated metal tube.

1 19. The multi-layer tube of claim 1 wherein  
2 the priming layer is a nylon primer having as a major  
3 constituent titanium dioxide.

1 20. The multi-layer tube of claim 1 wherein  
2 both the first and second polymeric layers comprise a low  
3 viscosity, low molecular weight Nylon 12 material.